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THE MACHINE TOOL INDUSTRY IN THE REPUBLIC OF KOREA**

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I. THE REPUBLIC OF KOREA

1. Population and living standard

The Republic of Korea (or South Korea) occupies the southern half of the Korean peninsula; it has more than 42 million inhabitants over an area of 100,000 km^2, or more than 400 inhabitants per km^2 - this is the highest population density in the world after Bangladesh and Taiwan.

In 1953, at the end of the war, Korea was featured among the poorer countries, coming after Cameroon and Senegal. Since then it has undergone rapid growth:

Table 1: Mean annual growth of the GNP
(per cent)

1954-1961	1962-1970	1971-1978	1979-1983	1984-1988
3.9	8.7	9.9	4.4	10.75

Since 1975, the mean standard of living in our country has outstripped the standard of living in Colombia, and then, successively, that of Argentina, Mexico and Brazil. In 1988, with more than $US 4,000 per head, the mean standard of living in South Korea, higher than that of Portugal, followed on the value for Greece.

2. Priority for human resources

South Korea lacks space (2,200,000 ha that can be cultivated); it is deprived of natural mineral or energy resources. On the other hand, Korea has given high priority to education and to the development of human resources.

Table 2: Pupils and students

	1945	1960	1970	1980	1985	1988
Primary	1 382	3 621	5 749	5 658	4 856	4 819
Secondary	85	802	1 909	4 168	4 935	4 824
University	8	97	163	564	1 192	1 289
Others	-	194	163	177	167	193
TOTAL (a)	1 475	4 716	7 985	10 568	11 151	11 126
Population (b)	16 000	25 000	32 240	38 120	41 050	42 200
(a) (b)	9%	18.8%	24.7%	27.5%	27.0%	26.3%

Source: EPB.

The average level of education has risen so quickly that more than 50 per cent of the Korean workers graduate from universities or high schools.

3. The eleventh trading nation of the world

At the beginning of the 1960s, Korea imported 10 times more than it exported. The foreign experts consulted by the Government advised the development of the export of agricultural products (rice!). In 24 years Korea has rebalanced its external trade, with the deficit giving way to a surplus from 1986 onwards, due to rapid growth in the export of manufactured products.

Korea alone imports more than all the African countries put together, since its imports exceed 50 per cent of the imports of the entire group of Latin American countries from Argentina to Mexico. In 1988, Korea became the eleventh biggest trading country in the world.

4. Debt and structure of national savings

In 1985, Korea was among the five countries of the world that were the most heavily indebted. But since 1986, the foreign debt has undergone rapid repayment, so much so that from 1990 onwards Korea's foreign assets will be equal to if not higher than its foreign debt. For financiers South Korea is no longer a risk country. Paradoxically, the foreign debt, which was preferred for a long time to a broader opening up to direct foreign investment, has enabled Korea to build up national savings which rose from less than 10 per cent of the GNP in 1962 to 30 per cent in 1983, and to almost 40 per cent in 1988. Since 1986, the level of national savings has been higher than the investments, thereby enabling Korea to develop its investments abroad.

In less than three decades, Korea has managed to turn ordinary manual labour into skilled labour on the basis of broad initiatives in education, training and apprenticeship.

The dynamic economic development in Korea is thus based on the systematic build-up of new and comparative advantages.

II. THE MANUFACTURING INDUSTRY IN KOREA

5. Growth and contribution of the manufacturing sector

The Japanese colonizers used Korea as an industrial relay base in their advance towards Manchuria and China. North Korea inherited the main heavy industrial bases, while South Korea acquired lighter industrial activities.

Between 1954 and 1988, the manufacturing sector in South Korea developed at a rapid rate: a mean annual figure of 14 per cent.

Table 3: Mean annual growth of the manufacturing sector
(per cent)

1954-1961	1962-1970	1971-1978	1979-1983	1983-1988
11.1	17.1	17.7	5.9	14.1

Source: Economic Planning Board (EPB), Bank of Korea.

As a result, the contribution by the manufacturing sector to the national product grew steadily:

From 5.3 per cent in 1954
To 29.9 per cent in 1983, and
To 31.6 per cent in 1988.

The contribution by the manufacturing sector to the creation of jobs has also been very considerable. It grew from:

8.8 per cent of the employed population in 1964
to 27.7 per cent of the employed population in 1988.

We see in this connection that between 1981 and 1988 manufacturing activities enabled us to create 64 per cent of the new jobs. 1/

The contribution by the manufacturing sector to foreign trade has been decisive, as can be seen above, in transforming a chronic and heavy deficit which the country had for more than 20 years into a situation of surplus (since 1986).

Table 4: Contribution by the manufacturing sector to foreign trade
(per cent)

	1961	1971	1980	1985	1988
Exports	22.0	86.0	92.3	95.0	95.0
Imports	-	-	44.0	60.0	70.0

Source: Bank of Korea.

6. From light to heavy industry

The rapid growth of the manufacturing sector in Korea is reflected by:

- The trends in structure, with the light industries gradually giving way to the heavy industries and chemical industries.

Table 5: Trends in the structure of the manufacturing industry
(contribution to the value added)

	1954	1964	1974	1983	1987
Light industries	83.5	67.3	54.4	44.9	35.6
Heavy and chemical industries	6.5	32.7	45.6	55.1	64.4
TOTAL	100.0	100.0	100.0	100.0	100.0

Sources: Bank of Korea and KDI.

1/ Source: Bank of Korea, Economic Statistics Yearbook (1989).

- Development of the relative contribution of the larger enterprises (employing more than 300 persons), on the one hand, and the small and medium-size industries, on the other, to manufacturing production.

Table 6: Manufacturing production index

	Manufacturing sector	AFI (agro-food industries)	Textiles Leather	Wood	Paper	Chemicals	Construction materials	Machines
1985 base	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
All enterprises 1988	165.5	132.4	139.2	141.3	154.1	149.5	144.1	215.0
SME 1988	152.3	137.3	151.2	118.6	135.9	130.3	147.8	181.5

Source: Bank of Korea

With the exception of the AFI, textiles and non-metallic minerals, the production of the larger enterprises is therefore progressing faster than that of small and medium-size enterprises.

- A change in the structure of foreign trade in manufactured products, machinery and capital goods resulting in growth of exports as well as imports.

Table 7: Differentiated trend in foreign trade (1980-1988)
Mean annual growth rates

	Exports	Imports
TOTAL	17.5	10.3
Of which, chemical	12.3	16.8
Of which, machinery and equipment	30.0	17.8

Source: Bank of Korea.

7. Dynamic development of the investments

The trend in investments reflects the intensity of the accumulation process, which is all the stronger since the process speeded up after the 1979-1981 crisis.

The mean annual growth rate for the gross formation of fixed capital attained 15.25 per cent between 1983 and 1988, while the mean annual growth rate for investments in the manufacturing industry attained 32 per cent during the same period. The investments in this sector, which were very much affected by the crisis, have made a vigorous recovery since 1984. They are now:

2,148 thousand million won, or 35.6 per cent of the total investments for 1978;
1,404 thousand million won, or 13.7 per cent of the total investments for 1981;
2,079 thousand million won, or 11.3 per cent of the total investments for 1983;
11,286 thousand million won, or 31.3 per cent of the total investments for 1988.

It is noteworthy that between 1983 and 1988 the investments were by non-housing construction and equipment.

Table 8: Trends in the structure of investments 1983-1986

	GFCF	Housing constructions	Transport equipment	Non-housing constructions	Capital goods
Mean annual growth rate	15.25	9.0	12.2	17.5	18.0

Source: Bank of Korea.

We see that almost 75 per cent of the investments in the manufacturing industry are devoted to the expansion of production capacities. In the engineering industry the figure is 78 per cent, which breaks up as follows:

61 per cent for expansion of capacity;
17 per cent for intensification, in the form of automation or R&D.

(Source: KOAMI Yearbook of the Engineering Industry for 1989.)

This is reflected by both the acceleration of the engineering industry and the import of capital goods.

The import of capital goods and transport equipment increased:

From $US 15,546 million in 1980-1982 (or 149 per year);
To $US 29,826 million in 1983-1985 (or 9,941 per year), and
To $US 52,024 million in 1986-1988 (or 17,341 per year).

The speedy growth of the engineering industry made it possible for national self-sufficiency to improve between 1983 and 1986.

Table 9: Trends in the self-sufficiency in engineering production
(per cent)

		1983	1984
Engineering sector		50.4	67.8
Including:	Metal products	62.5	86.0
	General machinery	41.5	48.0
	Electrical and electronic machinery	59.0	69.5
	Transport equipment	47.6	83.5
	Precision machinery	22.2	42.7

Source: Trade Statistics of the Engineering Industry, KOAMI (1989).

This leads us on to look at the mechanical and electrical industries sector.

III. THE MECHANICAL AND ELECTRICAL INDUSTRIES IN KOREA

8. Five sub-branches

The mechanical and electrical industries (engineering industry) come under heading 38 of the ISIC: this consists of:

Metal goods - ISIC 381
General machinery - ISIC 382;
Electrical machinery - ISIC 383;
Transport equipment - ISIC 384;
Precision machinery - ISIC 385.

9. Fast growth industries

The mechanical and electrical industries are those which among the manufacturing branches started at their lowest point in 1960, but which have also undergone the fastest growth rate:

Between 1960 and 1980; between 1980 and 1985, and between 1985 and 1988.

Table 10: Trends in manufacturing production per branch 1985 = 100.0

	Manuf. ind.	AFI	Textiles	Wood	Paper	Chemi-cals	Construc-tion materials	Metals	Mech. and elect. ind.
1960	2.1	6.7	2.1	7.5	6.3	0.8	4.1	0.8	0.4
1980	59.8	71.0	75.0	67.8	76.3	77.3	66.7	53.2	41.2
1985	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1986	165.5	132.4	139.2	141.3	154.1	149.5	144.1	137.0	215.0

Source: Bank of Korea and Yearbook of the Engineering Industries, KOAMI (1989).

The evolution of the five sub-branches of the mechanical and electrical industries is as follows:

Table 11

	38	381	382	383	384	385
1960	0.4	1.7	2.8	0.2	0.2	0.3
1980	41.2	55.1	33.3	39.2	36.9	79.6
1985	100.0	100.0	100.0	100.0	100.0	100.0
1988	215.0	133.0	202.0	269.0	198.0	240.0

Sources: Bank of Korea and Yearbook of the Engineering Industries, KOAMI (1989).

It should be noted that the production of the larger enterprises developed more quickly in the branch than that of the small and medium-size enterprises, with the production development index being as follows:

Table 12: Larger enterprises, small and medium-size enterprises, development of production

	Manufac-turing industry	Textiles	Wood	Paper	Chemicals	Mech. and electr. ind.
1985	100.0	100.0	100.0	100.0	100.0	100.0
1988 for all the bigger enterprises	165.5	139.2	141.9	159.2	149.5	215.0
1988, incl. SMI	152.3	159.2	118.6	135.9	130.3	181.5

Sources: Bank of Korea and Yearbook of the Engineering Industries, KOAMI (1989).

10. The leader industries

The dynamic nature of the engineering industries (38) reasserted itself following the recession and stagnation associated with the 1980-1981 crisis. This relates to:

Table 13: Production and value added

	Production in thousand million won	% 2/	Value added in thousand million won	% 2/
1978	5 119	24.2	1 985	24.2
1980	6 960	19.2	2 587	21.8
1982	11 616	22.5	4 379	25.3
1984	19 374	27.1	7 339	29.7
1986	28 681	31.2	10 784	32.8
1987	38 175	33.5	14 044	34.6

Source: Yearbook of the Mechanical and Electrical Industries, KOAMI (1989).

The number of enterprises and jobs

The mechanical and electrical industries are making relative progress both in terms of the number of enterprises and the number of jobs.

2/ In per cent of the total manufacturing production.

Table 14: Mechanical and electrical industries: enterprises and jobs

	1978	1981	1984	1987
Number of manufacturing enterprises (A)	29 864	33 431	41 549	54 389
Number of enterprises in sector 38 (B)	6 123	7 433	10 487	15 780
(B)/(A) (%)	20.5	22.2	25.2	27.4
Number of manufacturing jobs (C) (1000)	2 111	2 044	2 343	3 001
Number of jobs in sector 38 (D) (1000)	568	543	708	1 033
(D)/(C) (%)	26.9	26.5	29.0	33.4

Source: Yearbook of the Mechanical and Electrical Industries, KOAMI (1989).

Betweeen 1981 and 1987 the mechanical and electrical industries helped to create:

40 per cent of the new manufacturing enterprises;
61 per cent of the new manufacturing jobs.

The five sub-branches contributed to the creation of enterprises and the creation of jobs as follows:

Table 15

		1978		1987	
		Enterprises (units)	Jobs (1000)	Enterprises (units)	Jobs (1000)
Including:	38	6 123	568	15 780	10 331
	381	2 025	92.5	4 294	159.3
	382	1 603	83.7	4 333	172.9
	383	1 389	213.0	4 514	449.3
	384	807	126.1	1 832	203.9
	385	299	28.4	807	48.1

Source: Yearbook of the Mechanical and Electrical Industries, KOAMI (1989).

The five sub-branches are classed below as a function of the dynamic nature of the relevant creation of enterprises and jobs.

Table 16

	Creation of enterprises	Creation of jobs
381	5	4
382	2	1
383	1	2
384	4	3
385	3	5

Two sub-branches stand out, namely:

382 - non-electrical (general) machinery, and
383 - electrical machinery.

Trends in supply and demand and in foreign trade are recapitulated in the following table:

Table 17
(in millions of $US)

	1983	1985	1988	Annual growth rate 88/83
Production	18 791	24 290	70 831	30.0
Import	8 638	11 997	20 820	19.2
Total demand	27 430	36 288	91 641	27.0
Domestic demand	17 404	22 493	64 463	22.0
Export	10 025	13 794	27 178	15.3

Source: Idem.

The motivating force of a heavy domestic demand is such that national production increases faster than imports. The classification of the sub-branches is as follows for 1988 in terms of imports and exports.

Table 18

	Exports 1988	Imports 1988
381	4	5
382	3	1
383	1	2
384	2	3
385	5	4

First place in exports falls to the electrical industries, while the first place for imports goes to the engineering industry.

Investments in sector 38 rose from 1,900 thousand million won in 1985 to 4,105 thousand million won in 1988, their mean annual growth being slightly lower than that of the manufacturing industries. These investments stem to a massive extent from the larger enterprises: they average more than 97 per cent, with the exception of activities under 382 (machinery), where the percentage drops to 83.

These investments are distributed among the five sub-branches as follows:

Table 19: Distribution of investments

	1985	1988
381	2.4	3.0
382	7.8	7.0
383	53.0	56.0
384	36.8	33.2
385	3	0.8

Source: KOAMI Yearbook (1989).

In 1988, these investments related 61.1 per cent to expansion (new capacities and new products) and 14.3 per cent to intensification (automation and R&D), with the amounts invested in automation representing the highest percentages of investment in the engineering industry (11.3 per cent), and then in the electrical industries (9.4 per cent).

The funds devoted to R&D in 1988 were, globally, 8.2 per cent of the total investments; the mechanical and electrical industries alone employed in 1987 two thirds of the research workers in the manufacturing industry (15,333 out of 23,393), as well as 690 out of the 1,359 research institutes that the manufacturing industry possessed in 1987. 3/

11. Development supported by vigorous policies

The mechanical and electrical industries were embryonic at the end of the 1950s. Since the 1960s they have been given close attention by the Government, which is interested in motor cars and which in 1967 promulgated a law entitled "The Engineering Industry Promotion Act".

In May 1969, a presidential directive by President Park prohibited the negotiation of turnkey contracts with foreign firms so as to favour the development of national engineering and promotion of the engineering industries at the same time. This has been reflected by the establishment of a body responsible for considering draft contracts, as well as those contracts already signed, in order to identify the equipment already manufactured or likely to be manufactured on the spot.

Beginning from 1973, the heavy industries and chemical industries as a whole together with the mechanical and electrical industries were given a strong boost following President Park's solemn declaration, which has been reflected by a series of decisions:

3/ Of which 95 were in sub-branch 381
171 in sub-branch 382
281 in sub-branch 383
78 in sub-branch 384
36 in sub-branch 385, and
29 were unassociated with a particular sub-branch.

1973 - Creation of a heavy and chemical industries promotion committee;

1974 - Creation of the Changwon industrial zone giving priority to heavy engineering;

1974 - Launching of a vocational schools programme;

1974 - Creation of a national investment fund by which to distribute subsidized-interest funds for the so-called strategic industries.

Between 1973 and 1979 (assassination of President Park) the many-sided political boost worked in favour of the heavy industry sectors in an obligatory and discretionary manner. Several law/programmes were promulgated in relation to: motor cars, shipbuilding, electronics and machine building. Several specialized funds were set up, namely:

Machinery localization fund
Machinery export fund
Used machinery replacement fund.

The subsidized-interest credits of the national investment fund were used basically for the heavy and chemical industries and, more especially, the mechanical and electrical industries (51 per cent of the special loans allocated by the Government in 1979). Furthermore,

- These industries have benefited from tax privileges: elimination of the tax on profits for three years and a 50 per cent reduction on tax for the next two years, faster depreciation;

- These industries have been protected: the percentage of imports on which there were restrictions fell from 61.7 per cent in 1968 to 50.5 per cent in 1976 for the whole of the heavy and chemical industry sector, and dropped from 55.9 per cent to 35.4 per cent for the mechanical and electrical industries;

- These industries have also profited from the construction of industrial zones: at Changwon, and also at Banwol (1977: car parts and components) as well as at 20 or so other sites.

In three years - from 1975 to 1978 - investments in the heavy and chemical industries rose by a factor of 2.

Starting from 1979, the emergence of overcapacities led to authoritarian restructuring measures which concerned more especially the automobile industry and the industry producing equipment for energy production. Starting from 1980, a period of liberalization replaced the activistic and authoritarian period from 1973 to 1979. There was a trend towards less targeted policies that were less authoritarian but more uneven; tax reductions (on profits) were abolished; the only advantages remaining related to depreciation. Credits at subsidized-interest rates were condemned; the funds allocated to the National Investment Fund decreased (slowly), together (theoretically) with the special loans from the Korean Development Bank to the heavy industry sector. The products of the mechanical and electrical industries were in turn affected by the easing of restrictions on imports, though with some delay. Finally, in 1986, the law/programmes concerning the principal heavy industries gave way to a single Industrial Development Law, which called only for measures of encouragement that were neutral and indirect. According to the law, only two classes of industries were eligible for specific government aid: the industries for which limited support could impart a dynamic

approach and competition (rationalization industries), and the industries for which there was need to organize an orderly decline. 4/ However real the present easing of restrictions and the liberalization of industrial policies might be, we see at the same time that new and "less indirect" measures for supporting industry are being implemented against a background of:

- Promotion of high technology, 5/ which is the responsibility of a special committee within the Ministry of Technology, which is to establish a fund of 2,000 million won, making it possible to distribute subsidized-interest credits to the enterprises concerned;

- Creation of the modernization fund intended more especially (but not exclusively) for the small and medium-size enterprises (managed by the Korea Productivity Centre) or else a special fund for the adaptation of industrial structures, managed by the Small and Medium Industrial Promotion Corporation in conjunction with the Korean Federation of Small Businesses.

It is clear that while playing the game of easing restrictions the Korean Government has not given up the high priority fixed, with a view to the year 2000, for the mechanical and electrical industries.

Table 20: Trends in the manufacturing structure: perspective for the year 2000

	1981	1987	1990	2000	Annual growth rate 1982-1990	1991-2000
Machinery	10.8		12.7	14.7	11.2	9.6
Electronics	7.0		11.0	18.8	14.8	13.9
Automobiles	2.9		6.8	8.9	19.8	11.0
Shipbuilding	3.7		5.6	4.3	14.5	5.2
Subtotal	27.4	34.6	36.1	46.7		
Total for manufacturing industry	100.0	100.0	100.0	100.0		

Source: KDI.

IV. THE MACHINE TOOL INDUSTRY IN KOREA

12. Production - export - import - role and contribution of the machine tool industry

Machine tools include:

- Machine tools which work by cutting metal, such as lathes or milling machines;

- Metal forming machine tools, for example, presses.

4/ Source: Industrial policy in Korea: Review and Perspective, Kang Chul Kyu, KIET (1988).

5/ Machinery, electronics, microelectronics, aerospace, fine chemistry, new materials and biotechnology.

They are divided nowadays into:

- Conventional machinery, and
- Numerically controlled machine tools (NCMT).

The introduction on an increasing scale of electronics is being accompanied by the production of robots as well as more and more sophisticated systems for the automation of workshops (flexible workshops, factory automation, etc.).

Machine tool activity comes under 3823 of the ISIC system of classification (3821, 3822 and 3823) and corresponds to numbers 8456 and 8453 of the Korean (HSK) classification.

Within the engineering industry (ISIC 382), the contribution by the machine tool industry to the engineering industry (ISIC 382) and, all the more so, to the mechanical and electrical industries is quite modest. In effect, the machine tool industry contributes (1988)

To 0.8 per cent of the number of enterprises	)	
To 1.8 per cent of employment, and	)	for 38
To 1.2 per cent of production	)	
To 3.0 per cent of the number of enterprises	)	
To 10.8 per cent of the employment, and	)	for 382
To 3.1 per cent of the production	)	

This does not prevent the machine tool industry being of strategic importance without any comparison with the percentages stated above. In effect, it is an industry which having produced "machines to make machines" for such a long time is now tending to combine with electronics (hardware and software) in order to produce automated machinery systems that are more and more sophisticated and which belong to what is known today as "mecatronics". 6/

13. History and localization

Historically speaking, the machine tool industry was one of the least developed activities in Korea up to the 1970s. Almost all the machine-building plants were destroyed during the Korean war between 1950 and 1953. After the war, from 1955 onwards, a very old type of lathe (the belt model) was manufactured by the Korea Shipbuilding Company.

The first lathes of a more modern design produced in Korea were made by small local enterprises at the beginning of the 1960s. Following the growth of a national market, the first foreign technology import intended to improve the production of machine tools in Korea was made in 1966. But it was not until 1973-1974, when the Government decided to accord high priority to machine-building that the manufacture of machine tools was given a boost.

In 1974, the Government introduced a system of standards for machine tools. In 1977, the Government launched a programme for promoting metal cutting machine tools. In 1978, the Government formally recognized (with advantage into the bargain) 35 industrial firms as "machine tool specialists". Starting from 1974,

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6/ This is the title of one of the latest KIET publications, Seoul, October 1989 (in Korean).

the construction of the Changwon "heavy industry zone" made it possible to develop several new units for producing machine tools which are today among the most dynamic ones (19 industrial units in 1988). These units were set up or enlarged in order to meet the growing needs created, among other things, by the new investments in the mechanical and electrical industries. The available statistics enable us to calculate that machine tools represent about 11-12 per cent of the amount of total investments in sector 38 - the mechanical and electrical industries.

The machine tool industrial firms are first to be found in Seoul, but also in the inner and outer suburbs of the capital:

Seoul:	18 units)	
Inchon and Bucheon:	22 units)	62 units
Kyunggi-do:	22 units)	

The upswing of the 1970s was reflected by the expansion of the industry into the south-east:

Changwon:	19 units)	
Busan:	10 units)	42 units
Ulsan to Masan:	13 units)	

While less numerous enterprises have been established at:

South-West Centre:	12 enterprises
South-East Centre:	14 enterprises 7/

we should note the extensive presence of large Korean groups (Chaebol) in the machine tool industry, most of these larger groups being located at Changwon or Ulsan.

14. Enterprises

The machine tool industry is difficult to delimit with any accuracy inasmuch as:

- Some statistics confuse metal-cutting with woodworking machines;
- Manufacturers of components for machine tools also participate in the production of other classes of machinery.

The establishment of the Korea Machine Tool Manufacturers Association 8/ in 1979 has made it possible to improve matters.

In 1979, KOMMA was made up of 47 companies, while by June 1989 it contained 130, of which:

7/ In all: 130 enterprises recorded by the Korean Machine Tool Industry Yearbook (1989), published by the Korean Association of Machine Tool Producers, Seoul (including the enterprises turning out woodworking machines).

8/ KOMMA.

- 92 9/ were machine tool producers, with 64 metal-cutting machines, and 38 metal-forming machines;

- 34 manufacturers of machine tool parts and components; and

- 4 woodworking machine manufacturers.

The Korean Machine Tool Catalogue published by KOMMA listed the following in March 1989:

96 manufacturers of machine tools
32 manufacturers of machine tool parts and components, and
5 manufacturers of woodworking machines.

The catalogue also shows the distribution of manufacturers per type of machine:

Conventional lathes	8	manufacturers
Numerically controlled lathes	13	"
Automatic lathes	11	"
Other types of lathes	4	"
Machining centres	15	"
Milling machines	17	"
Numerically controlled milling machines	6	"
Vertical drilling machines	7	"
Radial drilling machines	6	"
Other types of drilling machines	9	"
Surface grinding machines	8	"
Other types of grinding machines	8	"
Sharpening machines	4	"
Other sharpening machines	6	"
Boring machines	4	"
Gear-cutting (hobbing) machines	2	"
Numerically controlled gear-cutting machines	2	"
Electro-spark erosion machines	4	"
Numerically controlled electro-spark erosion machines	4	"
Tool grinders	2	"
Metal saws and shears	10	"
Shapers	3	"
Special machines	16	"
Other metal-cutting machines	7	"
Mechanical presses	17	"
Hydraulic presses	11	"
Pneumatic presses	1	"
Other presses	11	"
Wire-drawing machines	3	"
Wire-rolling machines	5	"
Other metal-forming machines	12	"
Rolling machines	3	"
Machine tool parts	34	"
Castings and cylindrical parts for rolling machines	7	"
Robots	4	"

9/ It is difficult to quote the figure with accuracy, since it varies in the same brochure from 92 to 97, including (or not?) woodworking machinery manufacturers.

Among these enterprises 36 make numerically controlled machines.

In 1988, 97 enterprises that were members of KOMMA employed 18,803 persons:

(instead of 3 860 in 1974,
7 310 in 1978,
7 354 in 1982,
9 013 in 1985,
12 250 in 1986,
and 15 493 in 1987).

The number of employees doubled between 1974 and 1982 (eight years) and doubled again between 1985 and 1988 (three years).

For the most part these enterprises are small or medium-sized ones.

Table 21: Size of enterprise and employment 1988

Class of enterprise	Number of enterprises	Number of employees	Percentage Enterprises	Percentage Employees
< 49 empl.	21	768	21.7	4.1
From 50 to 99	29	2 097	29.9	11.2
From 100 to 199	27	3 667	27.8	19.5
From 200 to 299	8	2 010	8.2	10.7
From 300 to 499	4	1 664	4.1	8.8
From 500 to 999	5	2 935	5.2	15.6
> 1 000	3	5 662	3.1	30.1
TOTAL	97	18 803	100.0	100.0

Source: KOMMA.

Nevertheless, although nearly 80 per cent of the enterprises employ less than 200 persons each, 12 enterprises employ more than 50 per cent of the manpower; this imparts to the Korean machine tool industry a structure that is very different from that of the industries of Taiwan or Japan in that the mean employment per enterprise in the latter country is half as much as in Korea (1988): more than 180 employees per enterprise in Korea instead of 77 in Japan (1986). 10/

We see that the sub-contracting for machine tool production is much more developed in Taiwan and Japan than in Korea, with the proportion of the production sub-contracted by manufacturers being:

80.0 per cent in Japan,
70.0 per cent in Taiwan,
and only 27.9 per cent in Korea. 11/

15. Overall supply and demand

Table 22 retraces the trends in the overall supply and demand of machine tools from 1974 to 1988.

10/ Cf. Machine Tool Statistics Handbook, KOMMA (1989-1990).

11/ Data provided by KOMMA (October 1989).

Table 22: Machine tool supply and demand
(in thousands of millions of current wons)

Year	Production (A)	Exports (B)	Imports (C)	Domestic consumption (D)	(B) (A)%	(C) (D)%	Balance
1974	7.0	0.3	22.3	29.0	4.8	77.0	- 22.0
1976	11.0	0.2	49.1	60.0	1.7	81.9	- 48.9
1978	55.1	2.0	121.1	174.2	3.7	69.5	- 119.0
1980	56.0	13.7	104.2	146.5	24.6	71.2	- 90.4
1982	91.2	26.1	64.9	130.0	28.7	49.9	- 38.7
1984	117.2	17.8	111.6	271.0	10.1	41.2	- 93.8
1985	184.9	20.8	203.4	367.5	11.3	55.4	- 182.6
1986	320.4	23.8	308.2	604.7	7.4	51.0	- 284.3
1987	480.0	29.6	384.9	836.3	6.2	46.1	- 355.8
1988	462.5	38.9	426.7	840.3*	8.4	49.6	- 377.7

Source: Machine Tool Statistics Handbook.

* This makes Korea one of the first world markets in machine tools ($US 1,235 million in 1988).

The development of Korean machine tool activity changes according to the general movement shown above in connection with the high priority accorded to the machine industry, its impact on investments (in equipment) and so on. The production, which was insignificant in 1974, was stepped up by a factor of eight in four years, and then, after being affected by the crisis, rallied in 1981 and rocketed after 1984. The increase in production, basically due to the domestic demand, found an outlet, although a limited one, in exports during the crisis. Imports rose by a factor of seven between 1974 and 1979, declined afterwards and then grew rapidly from 1985 onwards. It is remarkable that in view of the strong rallying of domestic demand, production managed to maintain a level of self-sufficiency, or even to raise it. The ratio between imports and domestic demand (domestic consumption) changed from:

77 per cent in 1974, to 75.7 per cent in 1979, to 55.4 per cent in 1985, and to 49.6 per cent in 1988.

The interpretation of this table should take into account monetary parity, more especially over the last two years (1987 and 1988), to the extent that the value of the US dollar dropped from 789 won in 1987 to 681 won as an average in 1989. This assessment changes the poor progress noted between 1987 and 1988 into a net growth, even if we see a slight slowing down compared with 1986-1987.

16. World classification

Compared with the world manufacture of machine tools, Korean production is still modest; but it has sharply improved its ranking in the world classification.

In 1982, Korean machine tool production amounted to $US 158 million, i.e. 0.7 per cent of the world production ($US 22,370 million).

In 1988, Korean machine tool production amounted to US$ 597 million, i.e. 1.5 per cent of the world production ($US 38,047 million).

Between 1982 and 1988, the Korean machine tool industry moved from the twenty-second to the fourteenth place in the world.

CLASSIFICATION

	1982	1988
1.	Japan	Japan
2.	FRG	FRG
3.	USSR	USSR
4.	USA	Italy
5.	Italy	USA
6.	GDR	Switzerland
7.	Switzerland	GDR
8.	Great Britain	Great Britain
9.	France	France
10.	Rumania	Chinese People's Republic
11.	Chinese People's Republic	Taiwan
12.	Czechoslovakia	Spain
13.	Yugoslavia	Yugoslavia
14.	Canada	Republic of Korea
15.	Spain	Rumania
16.	Bulgaria	Brazil
17.	India	Poland
18.	Taiwan	Czechoslovakia
19.	Sweden	Canada
20.	Brazil	Sweden
21.	Austria	India
22.	Republic of Korea	Hungary

Source: Machine Tool Statistics Handbook, KOMMA (1989-1990).

Furthermore, Korean machine tool production has progressed at the fastest rate: it increased by 3.77 between 1982 and 1988:

Before Taiwan (production increased by 3.75)
Before Brazil and Spain (increased by 2.6)
Before Yugoslavia (increased by 2.3).

17. Two large categories of machine tools

The Korean machine tool industry produces:

Metal-cutting machines as well as metal-forming machines in proportions that are more or less constant:

- About 60 per cent are metal-cutting machines (55-70 per cent, depending on the year);

- About 40 per cent are metal-forming machines (45-30 per cent, according to the year).

Table 23: Trends in the production of machine tools according to the two large categories
(Value in thousands of millions of won)

	Metal-cutting		Metal-forming	
	Units	Value	Units	Value
1976	11 055	6.7	3 889	4.3
1978	24 980	36.2	11 424	18.8
1980	31 742	36.1	10 862	19.8
1982	17 987	56.9	18 906	34.2
1984	55 279	103.4	6 802	73.7
1985	17 920	112.8	9 764	72.1
1986	31 215	184.4	17 613	135.9
1987	191 332	293.3	30 419	186.7
1988	128 412	353.2	4 015	109.3

Source: Machine Tool Statistics Handbook, KOMMA (1989).

The number of units produced develops in a much more irregular fashion than their value. This applies to the production of small and very small-size machines such as metal saws or grinders: for example, 65,041 grinders and 40,354 metal saws in 1988.

This trend in the value enables us to ascertain the structure of production per major category of machine.

The metal-cutting machines divide up into:

	1986	1988
	per cent	
Lathes	39.4	36.1
Milling machines	15.7	17.0
Machining centres	11.5	13.0
Special machines	9.0	11.8
Grinders and sharpeners	7.0	7.2
Drillers	4.1	4.1
Electro-spark erosion machines	2.8	1.7
Saws	1.8	2.4
Other machines	8.7	6.7
TOTAL	100.0	100.0

The metal-forming machines divide up into:

Presses	86.5	83.7
Rolling machines	6.2	6.0
Wire-drawing machines	3.7	0.2
Other machines	3.6	10.1
TOTAL	100.0	100.0

Korean production is:

- Highly concentrated on presses in the metal-forming machine class;
- More diversified in the metal-cutting machine class, the production of lathes representing in this case more than a third of the activity.

18. Conventional machines and numerically controlled machines

Among the metal-cutting machine tools we distinguish:

- Standard machine tools;
- Numerically controlled machine tools.

Korea produced its first numerically controlled machine tools at the beginning of the 1980s:

- In 1981: the first numerically controlled lathes and first machining centres;
- In 1982: the first numerically controlled milling machines;
- In 1987: the first numerically controlled grinding machines;
- In 1988: the first numerically controlled drilling machines;
- In 1988: the first numerically controlled gear-cutting machines;
- In 1988: the first numerically controlled electro-spark erosion machines;

In terms of value the numerically controlled machines represent:

	1986	1988
In percentage of the value of metal-cutting machines	33.0	34.9
In percentage of the total value of machine tool production	19.3	26.7

This production is rapidly developing: a recent study 12/ estimates that the proportion of numerically controlled machines among the products will reach 44 per cent in 1990 and 60 per cent during the decade.

19. Exports

Korean machine tools have been exported since the mid-1970s. These exports were developed between 1977 and 1983, after which they stagnated and then again made rapid progress from 1986 onwards.

12/ Mecatronics, KIET (October 1989).

Table 24: Trends in export
(in millions of $US)

1977	1 641
1978	4 187
1980	22 989
1982	34 920
1984	21 569
1985	23 434
1986	27 727
1987	37 469
1988	56 969

Exports related basically to metal-cutting machine tools:

93.1 per cent in 1986
87.3 per cent in 1987, and
89.7 per cent in 1988.

The principal machine tools exported are:

- Lathes: 74.6 per cent in 1986 and 58 per cent in 1988
- Machining centres: 6.6 per cent in 1986 and 13.5 per cent in 1988
- Milling machines: 3.7 per cent in 1986 and 3.8 per cent in 1988
- Presses, which rose from 6.6 per cent in 1986 to 10.3 per cent in 1989.

Table 25: Exports of numerically controlled machine tools
(in millions of $US)

	Total exports (A)	Including numerically controlled machines (B)	(B)/(A) %
1981 13/	30.6	2.1	6.8
1982	34.9	10.0	28.6
1983	21.4	5.6	26.1
1984	21.5	7.6	35.3
1985	23.4	7.1	33.3
1986	27.7	13.9	50.1
1987	37.4	22.5	60.1
1988	56.9	34.2	60.1

It is the rapid progress in numerically controlled machine tools exports which lies at the basis of the overall growth of exports from 1985 onwards.

13/ 1981 was the year in which Korea exported numerically controlled machine tools for the first time.

The export of numerically controlled machine tools relates primarily to:

- Lathes: 46.1 per cent of the exports for 1988 (out of 60.1 per cent);

- Machining centres: 13.5 per cent of the exports (out of 60.1 per cent).

The principal destinations of the machine tools exports are as follows:

- By major region:

	1978	1983	1988
America	47.3	41.4	39.7
Asia	22.3	35.3	28.1
Europe	0.4	14.7	28.5
Other	30.0	8.6	14.3
Total	100.0	100.0	100.0

Europe has claimed its place to the detriment of the other regions - Asia and to some extent America.

- By country (1988):

	%
United States	33.9
Japan	16.9
FRG	9.8
Great Britain	5.0
France	4.9
Netherlands	2.6
Singapore	2.4
Hong Kong	2.1
Taiwan	2.0
Italy	1.8
Canada	1.8
Other countries 14/	17.1

The main clients for Korean machine tools are also the most industrialized countries.

20. Imports

The imports relate to all the classes of machine tools:

- Metal-cutting machines and metal-forming machines;

- Standard machines and numerically controlled machines.

14/ Among which are Chile, Sweden and Saudi Arabia.

Table 26: Trends in the import of machine tools 1977-1988
(in millions of dollars US)

	Total (A)	Including metal-cutting machines (B)	Metal-forming machines (C)	Numerically controlled machines (A')	Growth-rate/year of (A')
1977	152.6	104.9	47.7	1.2	91.3
1978	250.2	156.0	94.1	3.4	179.2
1979	310.8	200.0	110.8	26.6	662.6
1980	173.7	91.5	82.2	3.7	85.6
1981	130.2	101.2	29.0	11.6	208.1
1982	86.7	47.9	38.8	3.9	65.9
1983	139.7	103.8	35.9	9.6	142.5
1984	135.0	92.6	42.4	32.6	237.9
1985	228.6	150.5	78.1	25.6	21.5
1986	321.7	202.4	119.3	36.2	41.2
1987	486.1	340.6	145.5	80.3	122.0
1988	609.2	464.2	145.0	96.1	19.6

Source: Machine Tool Statistics Handbook, KOMMA (1989-1990).

The import relates more to metal-cutting machines than metal-forming machines. Metal-cutting machines constitute:

30.9 per cent of the total imports for 1977;
47.3 per cent of the total imports for 1980;
25.1 per cent of the total imports for 1983;
34.2 per cent of the total imports for 1985;
33.3 per cent of the total imports for 1986;
29.9 per cent of the total imports for 1987;
23.8 per cent of the total imports for 1988.

Among the metal-cutting machines the main imports concern:

Grinding and sharpening machines: 16.9 per cent in 1986 and 22.1 per cent in 1988;

Lathes: 9.4 per cent in 1986 and 10.0 per cent in 1988;

Drilling machines: 6.8 per cent in 1986 and 5.5 per cent in 1988;

Milling machines: 6.2 per cent in 1986 and 5.1 per cent in 1988.

Imports relate to all of the classes of machines while exports relate only to a few categories.

The import of numerically controlled machines was, successively:

0.7 per cent of the total in 1977 (in value);
2.1 per cent of the total in 1980;
6.9 per cent of the total in 1983;
11.2 per cent of the total in 1985;
16.4 per cent of the total in 1986;
16.5 per cent of the total in 1987;
15.8 per cent of the total in 1988. 15/

First and foremost, this relates to lathes, though also to machining centres, drilling and milling machines.

The main origin of the machine tool imports is as follows:

- By major region:

	1978	1983	1988
America	6.0	7.5	14.8
Asia	80.7	81.1	65.2
Europe	13.3	11.4	19.2
Other	-	-	0.8
Total	100.0	100.0	100.0

- By country (1988):

	%
Japan	60.9
USA	14.7
FRG	12.0
Taiwan	4.3
Switzerland	3.2
Italy	1.1
Great Britain	1.1
Others:	2.6
(of which France: 0.4 per cent)	

Japan alone provided more than 60 per cent of the machines imported, while Japan, the United States and Germany together provided 87.0 per cent; Taiwan held the fourth place as a supplier.

15/ It will be noticed that Korean exports of numerically controlled machine tools made greater headway during the 1980s than did the imports. Between 1981 and 1988, while the imports were increased by 8.3 (they went from $US 11.6 to $US 95.0 million), the exports were increased by a factor of 11.6 (from $US 2.1 to $US 34.2 million).

V. THE MACHINE TOOL INDUSTRY IN KOREA: PRICES - COSTS - TECHNICAL STANDARD - PERSPECTIVES

21. Prices

The large number of models available in each category of machine tool makes it difficult to analyse prices. Reference is thus made here to international data and comparisons supplied by the Ministry of Commerce and Industry of the Republic of Korea.

The first (May 1989) concerns five categories of machine tools whose prices are compared with those of Taiwan and Japan.

Table 27: Comparison of prices: Korea - Taiwan - Japan
($US)

	Korea	Taiwan	Japan
Conventional lathes (400 x 1 000 mm)	5 800	5 100	7 500
Milling machine (450 x 150 mm)	3 600	3 200	4 700
Numerically controlled lathes	53 000	46 000	69 000
Machining centres (table size: 1 250 x 400 mm)	59 000	52 000	74 000
Presses (200 t)	114 000	100 000	150 000

Source: Ministry of Commerce and Industry via KOMMA.

The prices of Korean machines are higher than the prices of Taiwanese machines but lower than those of Japanese machines. It is also necessary to take account of the respective performances of the various machines.

That is why the data supplied by the Ministry of Commerce and Industry and reproduced in the recent study by KIET on mecatronics are of such value.

Table 28: Comparison of prices and quality of Korean machine tools
(prices in thousands of $US)

Machines	Price			Quality and performance
	Korea	Japan	Taiwan	
Lathes (medium size)	8.5 (100)	9 (106)	5.7 (67)	Performance and precision identical to that of rival firms, but there are problems concerning the quality of certain parts due to inadequately developed technologies in the field of heat treatment.
Milling machines	15.6 (100)	18.1 (116)	11.6 (74)	

Table 28: (Continued)

Machines	Price			Quality and performance
	Korea	Japan	Taiwan	
Drilling machines	6.6 (100)	7.1 (108)	4.5 (68)	Performance and precision of international standard. Inadequacies relating to software and overall structure.
Milling machines	85.0 (100)	102.0 (120)	77.0 (91)	
Grinding machines	8.5 (100)	7.5 (88)	4.8 (56)	Inadequate strength and durability.
Gear-hobbing machines	28.0 (100)	33.6 (120)	25.0 (89.0)	
Electrode-spark erosion machines	20.0 (100)	26.0 (130)	18.0 (90)	
Numerically controlled machines	62.5 (100)	69.2 (111)	41 (66)	Fairly frequent breakdowns. Problems related to the fact that the national mastery of numerical control techniques is still imperfect.
Machining centres	120 (100)	145 (121)	110 (92)	Products still relatively recent. Precision still imperfect.
Special machines	64.0 (100)	96.0 (150)	58.0 (91)	Problems with technological design and precision.
Presses (100 t)	29.0 (100)	35.0 (121)	26.0 (90)	Products of relatively old design; problems with precision and strength.
Rolling mills	1 200 (100)	1 690 (141)	1 000 (83)	
Pipe-bending machines	17 (100)	25 (147)	16 (94)	
Wire-drawing machines	70 (100)	130 (186)	60 (86)	Quality comparable to foreign standards for "soft" wires. Problems with precision (and cutters) in the case of hard wires.

These data agree with the first price comparisons. Korean machines are more expensive than Taiwanese machines and less expensive than Japanese machines. While Japanese machines take the lead through their very high quality, competition with Taiwanese machines depends on costs, organization of the industry and relative advances in one area or another in mastery of the technology.

22. Costs

The extent of sub-contracting is probably a favourable factor which reduces production costs in Taiwan: in fact, the production of machine tools is 70 per cent sub-contracted in Taiwan (80 per cent in Japan), as compared with 27.9 per cent in Korea (data from Ministry of Commerce and Industry).

In broader terms, it is generally considered that wage increases have a significant impact on industrial activity.

According to a recent study, 16/ the rate of growth of labour costs per unit product in Korean manufacturing industry has been as follows:

	1986	1987	1988	1989 (E)
Growth rate of wages (A)	9.2	11.5	21.5	16.5
Growth of labour productivity (B)	17.6	13.3	16.1	14.7
Growth rate of cost of labour per unit product (A - B)	- 8.4	- 1.8	5.4	1.8

In the engineering and electronics industries, this gives the following results:

	1986	1987	1988	1989 (E)
(A)	8.7	8.4	21.4	14.9
(B)	28.4	16.7	17.4	17.1
(A - B)	- 19.7	- 8.3	4.0	- 2.2

According to the same report, the cost of labour per unit product in 1988 fell by 6.5 per cent in the electronics industry and increased by 7 per cent in the motor industry. In the machine tool industry, according to the Statistical Manual 1989-1990 (op. cit.), it appears that from 1986 to 1988 the trend in labour costs and productivity was as follows.

The labour costs (compared with the total costs of production) fell from 16.44 per cent in 1987 to 15.03 per cent in 1988, 17/ while the rate of growth of labour productivity was higher than the rate of growth of labour costs.

16/ By a private research institute.

17/ Of which 12.41 per cent was for wages in the true sense in 1987 and 11.58 per cent in 1988.

	1986	1987	1988
Rate of growth of labour productivity (%)	17.5	22.5	21.9
Rate of growth of labour costs (%)	12.7	20.8	20.6

It thus seems that the machine tool industry is not one of the sectors greatly affected by wage increases in recent years. 18/

It is true that the machine tool industry has a very recent park of machines:

1,864 machines less than 5 years old (36.1 per cent);
2,820 machines less than 10 years old (5 to 10) (54.5 per cent);
370 machines less than 15 years old (10 to 15) (7.1 per cent);
109 machines over 15 years old (2.3 per cent).

The industry is one which is in full swing and whose production capacity has essentially been installed or renewed since the beginning of the 1980s.

23. Technological updating

Catching up in the mastery of technology, particularly advanced technology, is the high priority which the Korean machine tools industry has set for itself.

While it is true that the progress achieved in 15 years has been significant and rapid, there are no grounds for complacency so long as international competition continues to be the permanent point of reference, particularly Taiwan, a close competitor, and Japan, which is the leading supplier and leading producer in the world (in quantity and in quality).

The general assessment by the Ministry of Commerce and Industry is based on this international reference.

18/ It may also be noted that the net profit ratio (compared to sales) increased from 2.65 per cent in 1986 to 4.31 per cent in 1988, while dividends in relation to net profits increased from 4.32 per cent to 18.28 per cent.

Table 29: Comparisons between Korea - Taiwan - Japan

	Korea	Taiwan	Japan
Domestic demand (millions of $US) 1988	1 109	589	5 686
Production (millions of $US) 1988	597	695	8 643
Number of enterprises	97	200	800
Level of sub-contracting (%)	27.9	70.0	80.0
Design techniques	Simple copy and imitation	Imitation	Original creation
Production and assembly techniques	Quite good precision but electronic equipment still inadequate	Inadequate precision and durability	Very high quality
Production range	First stage of localization for some numerically controlled machines	Fairly wide range	Advanced technology
Rate of integration (%)			
- Conventional machine tools	95.0	95.0	100.0
- Numerically controlled machine tools	65.0	75.0	100.0

Source: Ministry of Commerce and Industry (November 1989).

Another comparative evaluation is supplied by KOAMI. 19/

19/ Korea Society for the Advancement of Machine Industry.

Table 30: Quality comparison of main machine tools

	Type of product	Precision	Durability	Operational flexibility
Conventional machine tools	Lathes	A	A	A
	Milling machines	A	A	B
	Drilling machines	A	A	A
Numerically controlled machine tools	Lathes	A	A	B
	Milling machines	B	A	B
	Machining centres	B	B	A

A = Corresponds to level of advanced countries.
B = A little below the level of advanced countries.

Problems still remaining in the construction of conventional machines are now minor even if there are still some weak points (for example, relating to heat treatment).

24. The case of numerically controlled machines

Major problems are presented by the production of numerically controlled machines of international standard.

In the field of numerically controlled machine tools and electronics, Korea has a great deal of catching up to do.

Table 31: A comparison of numerically controlled and electronic machines in the advanced world and Korea

	Numerically controlled machines		Electronic	
	World	Korea	World	Korea
1930	High-speed lathe		Vacuum tube	
1950	Development of NC machines		Analogue computer Digital TR	
1960	Commercialization of NC machines	Production of multi-purpose machine tools	Integrated circuits Microprocessors	Import of computers
1970			Minicomputers	Transistor
1973	DNC systems	Import of NC machines	LSI	IC

Table 31: (Continued)

	Numerically controlled machines		Electronic	
	World	Korea	World	Korea
1976	CNC machine tools	Research into the production of NC machines	Large capacity microcomputers	Small digital calculators
1979	Development of robots and research into artificial brains			MSI
1980		Production of CNC machines	Experiment in connecting large-capacity computers with robots	
1983	Unmanned automation	Basic research into CNC systems RNC and DNC		LSI and large-capacity computers

Source: Industrial Development Bank (Seoul) Industrial Technology (December 1988).

This table highlights the extent to which Korea was initially behind:

- Twenty years for the production of numerically controlled machines;
- Sixteen years for the production of integrated circuits (IC)

and thus, despite the speed of catching up, the extent of the stages which still have to be covered.

One way in which this is reflected is in the differential trends in the rate of localization of machine tools.

Table 32: Trends in the rate of localization of machine tools

	1980	1981	1982	1983	1984	1985	(1989)
Conventional machines							
Lathes	85	90	92	92	95	95	95
Milling machines	80	80	83	85	88	88	-
Grinding machines	70	80	84	87	90	90	-

Table 32: (Continued)

	1980	1981	1982	1983	1984	1985	(1989)
NC machines							
Numerically controlled lathes	20	20	39	41	43	44	47.1
Machining centres	-	-	45	48	50	52	52.5
Electro-spark erosion machines	-	-	-	-	-	-	10.8

Source: KIET.

These data, which are more precise than the overall data given in table 28, show the relatively slow headway made in of mastering production of the main parts and components of numerically controlled machine tools which, until 1988, were largely imported.

Table 33: Parts and components of numerically controlled machines

	Lathe	Machining centre	Electro-spark erosion machine
Control system for numerical control	15	13.2	40
Servo motor and driver	10	10	5
Spindle motor and driver	17	8.6	-
Ball screw and curving coupling	4.1	4.5	1.5
Bearings	1.1	2.2	3.7
Hydraulic components	5.7	5.8	-
Oil cooler	-	3.2	4.0
Electric power generator	-	-	3.5
TOTAL imported parts	52.9	47.5	89.2
TOTAL local parts	47.1	52.5	10.8
TOTAL	100.0	100.0	100.0

Source: KIET.

Numerically controlled electro-spark erosion machines have been produced in Korea since 1988; the newness of this manufacture together with its complexity explain the low rate of localization. As far as other numerically controlled machines are concerned, the stagnation in the rate of localization for several years shows the size of the obstacle to be overcome, namely what constitutes the "hard core" of the numerical control system.

This obstacle, the complex package of technologies to be mastered, has been the subject of a systematic and detailed technical and paratechnical analysis in order to measure the time lag and at the same time identify solutions.

Table 34: Numerically controlled machine tools: Identification of technical problems and their solutions

	Major sectors	Significant components and processes	Essential techniques, equipment and components	Gap compared with advanced countries	Methods for acquiring techniques
NUMERICAL CONTROL	Hardware	Equipment	CPU programme control unit	C	N
			Monitor and keyboard	C	I
			PC programmable controller	B	N
		Servo motor	Motor	E	I
			Transformer	D	N
			Position and speed sensor	E	I
	Software	Tool related	To the servo motor	B	N
			Calculation for control of multiple axes	B	N
		Linked to peripheral control	Control sequences	B	N
			Interface	C	N
		Specific software	Graphic displays	B	N
			Automatic programming of numerical control	C	N
			Consumer software	C	N

Table 34: (Continued)

	Major sectors	Significant components and processes	Essential techniques, equipment and components	Gap compared with advanced countries	Methods for acquiring techniques
TECHNICAL CONCEPTION AND PROCESSING	Technical design	Types of machines (numerical control)	Machining centre	B	N
			Lathe	B	N
			Milling machine	C	N
			Electro-spark erosion machine	D	I
		Mechnical components	Cutting tools	E	N
			Spindle and bearings	E	I
			Structuring	D	I
			Transfer system	D	I
			Hydraulic components	E	I
	Manufacturing and assembly techniques	Production operations	Die casting	D	I
			Heat treatment	D	I
			Cutting and finishing	B	N
			Measurement and quality control	B	N
		Automation	Automation of conception and design	D	I
			Production automation	B	N

Source: KIET. Parts and Components Industry in Korea (December 1988).

- Measurement of lag behind advanced countries:

  A: same level
  B: one to three years behind
  C: three to five years behind
  D: five to 10 years behind
  E: more than 10 years behind

- Desirable method of acquiring technology:

  N: development undertaken in Korea
  I: technique to be imported.

25. Acquisition of techniques

The acquisition of advanced technologies is achieved both through research, development and national apprenticeship as well as recourse to foreign technologies, in the form of technical agreements, joint ventures, etc.

In the context of a major thrust towards heavy industry, the Government initially gave preference to large groups and large companies established at or near Changwon, which today predominate in the production of numerically controlled machine tools. It is the inadequate sub-contracting system containing small and

medium enterprises of a high technical level which today presents problems (time lag in the localization of parts and components).

It is for this reason that the Government has set up various channels of technical assistance and financial support in order to raise the technical level of small and medium enterprises in the sector.

Several funds are administered for this purpose by the Korea Federation of Small Businesses and the Korea Productivity Center, while agencies such as the Korea Technology Development Corporation have the task of participating in the creation or increase of capital of small and medium high-technology enterprises.

A small enterprise (45 people) set up at the end of 1986 and which will soon bring out a numerically controlled lathe, 19a/ for example, has benefited from the capital investment of KTDC, has been selected by the Ministry of Commerce and Industry in the context of the "technical integration of small and medium enterprises" and has also been singled out by the Bank of Seoul as "a small enterprise with a great future", etc.

In addition, successive development programmes for high-technology machine tools have been formulated or supported by the Government (Ministry of Commerce and Industry). On the one hand, they concern new types of machines:

- For 1989: a numerically controlled gear-hobbing machine, and a numerically controlled vertical lathe;

- For 1990-1991: a numerically controlled multi-blade lathe; a numerically controlled machine for sharpening cutting tools.

They also concern integration of parts and components:

- For 1989: NC controller, servo motor;

- For 1990-1991: parts and accessories for NC controller.

Not insignificant results have been obtained from R&D in Korea, as shown by the statistics drawn up by the Ministry of Commerce and Industry.

Table 35: Origin of technologies utilized by the machine tool industry

	Foreign import				Local	
	Japan	United States	Other	Total	development	Total
1 Lathes	9	-	-	9	1	10
Milling machines	8	1	-	9	2	11
Drilling machines	2	-	-	2	2	4
Boring machines	2	-	-	2	1	3
Grinding machines	5	1	-	6	5	11
Gear-hobbing machines	2	-	-	2	2	4
Machining centres	1	-	-	1	2	3
Numerically controlled machines	5	-	2	7	12	19
Other	3	-	-	3	5	8
SUBTOTAL	37	2	2	41	32	73
(%)	(50.8)	(2.7)	(2.7)	(56.1)	(43.8)	(100.0)

19a/ Keum Dan Engineering Company Ltd. Source: KTDC.

Table 35: (Continued)

	Foreign import				Local	
	Japan	United States	Other	Total	development	Total
2 Presses	8	1	-	9	5	14
Rolling mill	-	2	1	3	2	5
Shearing machine	-	-	1	1	2	3
Wire-drawing machine	1	-	-	1	2	3
Other	1	1	-	2	5	7
SUBTOTAL	10	4	2	16	16	32
(%)	(31.3)	(12.5)	(6.3)	(50.0)	(50.0)	(100.0)
TOTAL	47	6	4	57	48	105
(%)	(44.8)	(5.7)	(3.8)	(54.3)	(45.7)	(100.0)

Source: Ministry of Commerce and Industry.

Furthermore, data provided by the Association of Machine Tool Manufacturers relate exclusively to the acquisition abroad of technology. They draw a distinction between "technical agreements" (licensing, know-how, technical assistance contracts) and "joint venture" agreements which customarily include technical agreements. These data:

- Confirm the predominating nature of the Japanese partner, who monopolizes 75 per cent of technical agreements and 75 per cent of joint ventures;

- Bring out the recent and rapidly progressing nature of technical agreements and joint ventures:

  Out of 39 technical agreements listed by KOMMA,

  26 or 66 per cent were signed in 1988 and 1987,
  9 or 23 per cent were signed in 1986 and 1985,
  4 or 11 per cent were signed before 1985.

  Out of eight joint ventures counted, five were set up between 1986 and 1988, i.e. 62 per cent.

- Confirm the high priority attached to the mastery of numerical control systems, as reflected in the creation of a joint venture between the Whacheon Machinery Works Co. Ltd. - Kolon Trading Company and Fanuc Ltd. (leader of numerical control systems in Japan).

And through the establishment of another joint venture between five Korean manufacturers of machine tools: KIA, DAEWOO, DOOSAN, KIHUNG and DONG YANG and the American company ALLAN BRADLEY to produce numerical control systems, servo motors and servo control systems.

It is the TONG IL Corp., however, which seems to have been the first Korean company to master, with German assistance, the production of numerical control systems.

26. Production of robots

This is where we come to one of the modes of modern industry where hardware and software, mechanics and electronics (mecatronics) all join up. Korea, which is engaged in gaining mastery of numerical control systems, has embarked on the manufacture of robots.

Table 36: Supply and demand of robots in Korea

	1984	1985	1986	1987	1988 (P)
Production (units)	2	34	126	530	780
(Millions of won)	40	850	3 400	24 300	31 980
Imports (units)	46	123	101	177	210
(Millions of won)	1 060	3 150	2 730	4 300	8 520
Exports (units)	-	-	35	160	110
(Millions of won)	-	-	950	8 210	4 400
Domestic demand (units)	48	157	192	547	880
(Millions of won)	1 110	4 000	5 180	20 390	36 100

Source: "Mecatronics", p. 121, KIET, October 1989.

Several Korean manufacturers have embarked on this new production.

Table 37: Producers and production of robots

Companies	Types of products	1987 production in units and (millions of won)	Foreign technical agreements
Samsung Aeronautics		93 (2 230)	
Huandai Robot	Spot welding	198 (9 620)	
Daewoo H.I.	Spot welding and other	17 (365)	MIT (USA) Control Engineering
Goldstar Industrial Electric		40 (420)	Hirata (Japan)
Goldstar El-Machine		20 (210)	
Fanuc Korea		13 (552)	Fanuc (Japan)
Doosan Machine	Spot welding. Handling	34 (1 250)	Yaskawa (Japan)
Kia Kigong	Welding. Handling	- -	Kawasaki (Japan)

Source: "Mecatronics", KIET, October 1989.

KIET makes no comment on the incompatible nature of the data shown in the two preceding tables, which nevertheless make it possible to see that this new production is the concern of large groups relying on foreign technology, basically Japanese. 20/ Daewoo Heavy Industries has just inaugurated a second factory (in Changwon) (autumn 1989), at a total cost of 10 billion won, which will produce, annually:

- 250 robots (agreements with FANUC);
- 400 machining centres;
- 30 laser machines;
- 650 robot control systems;
- A large amount of other automation-related equipment (factory automation).

This new factory will produce all its components on site from 1991, as well as having a large production capacity for PLC (agreements with Toyota-Koki) (Korea Economic Journal). This will enable DHI to devote its first factory in Changwon to the production of numerically controlled machine tools.

27. Entry into industrial automation (FA)

Robots, after numerically controlled machines, constitute elements of industrial automation (factory automation or FA). A KIET study 21/ shows that in FA, Korea would be in 1988 at a level comparable with that of Japan in 1980, somewhere between the starting point of LCA (low-cost automation) and the target of CIM (computer-integrated manufacturing). Korea which is multiplying the acquisition of individual automated machines is probably not very far from the starting point. It is true that the information available on this question is somewhat fragmentary and frequently relates to automation of storage systems. It is known, however:

- That the first factory automation systems were introduced into Korea as part of the defence industry (aerospace in the United States and Great Britain);
- That FA is being developed more rapidly in the machine industry (including machine tools) and in the transport equipment industry;
- That, for the time being, the implementation of FA automation requires:
  - Foreign supplies in 53.5 per cent of cases,
  - Leasing in 28.7 per cent of cases,
  - National supply in only 17.8 per cent of cases;

20/ The rate of localization of robots is still low: between 35 and 51 per cent for robots with three or four axles and 22 to 27 per cent for robots with five axles.

21/ In Korean, an analysis of which the Korea Herald provided in English on 5 November 1989.

- That even if the process affects many small and medium industries, 22/ it is primarily linked to the dynamics of large groups.

According to KIET, contrary to what is happening in Japan, the primary reason for automation is not, in Korea, the reduction of labour costs but improvement of quality and increased productivity.

The size of wage increases since 1987, even if it still does not justify the cost of certain factory automation installations, 23/ has given rise to an awareness in Korea of the urgent need to enter or actively prepare to enter a new phase characterized by automation. Korean industry is facing several problems: mastery of industrial engineering and software, together with lack of highly qualified staff, a survey of whom needs to be made. In this connection, the Government launched a project to assess the demand for industrial automation; it has set up an automation centre within the Korean Productivity Centre in order to train high-level personnel; it has also entrusted Seoul National University with a project for research into automation, the results of which will be published in 1990.

Meanwhile, Korean industry is stepping up the introduction of new products for mastering new pivots of factory automation. This is the case of PLC (programmable logic controllers), demand for which was expected to rise from 100 billion won in 1989 to 180 billion won in 1990. Daewoo Heavy Industries, Samsung Aerospace, Goldstar Instrument & Electric Co. were already producing PLC. Hyundai Electronics, in a joint venture with Allan Bradley, will open a production unit for PLC at the end of 1990, while KOLON is building a production unit at KUMI and expects a second production unit for PLC at Kimchon to open in 1990. 24/

28. Perspectives. The battle for mastery of high technologies

The Korean machine tool industry which has entered the era of numerical control and industrial automation is, at the beginning of 1990, a dynamic and vigorous industry:

- Opening up new plants;

- Expanding manufacturing ranges;

- Mastering new technologies.

22/ For example, two small and medium industries visited which manufacture fuses for electronic devices, are in the process of being automated. The first will have completed its automation in 1991 and the other in 1990. (Seoul, 17 November 1989.)

23/ According to KIET, investments of that kind should be recovered in less than four years; in fact it is often the case that the effective recovery period in Korea is four to 10 years which calls into question the economic rationale for these investments.

24/ Korea Economic Journal of 27 November 1989 and Korea Herald of 5 November 1989.

For example:

- Daewoo Heavy Industries opened in March 1989 in Changwon a new plant (10 billion won) whose turnover should reach 200 billion won, which will produce robots (250), machining centres (650), robot controllers, etc. ...

- Samsung Shipbuilding & Heavy Industries inaugurated in October 1989 a factory (cost: 30 billion won) producing presses and machining centres.

- Doosan Machinery is making an investment for the continuous production of six new models of numerically controlled lathes and machining centres.

- Goldstarcable is investing 20 billion won to increase its production capacity of presses.

- Daedong Heavy Industries has just installed several production lines for machine tools at its Chingu factory.

- Korea A.B., in a joint venture with Bradley, has installed an annual production capacity of 3,000 numerically controlled lathes.

Some firms are investing abroad: this is the case of Tong Il which, as a joint venture, is building a factory for the production of machine tools and machine tool components at Quing Dao in China.

Other enterprises are forming associations (10 Korean manufacturers of machine tools) to supply the machines needed by manufacturers of precision moulds (moulds for electronics, watch cases): surface grinders; drilling machines, milling machines, mini-machining centres. 25/

This dynamism is promising, given that in 1989 the Korean economy is experiencing a period of slower growth which could continue into 1990. The production of machine tools, which had grown at a rate of 21 per cent during the first half of 1989, has in fact declined since August. Korean machine tool manufacturers reacted immediately by proposing leasing systems for small and medium industries in particular, and by turning towards exports. Daewoo Heavy Industries and the Tong Il Corp. set export targets for 1990 50 per cent higher than in 1989. The Whacheon Machinery Works has doubled its export targets for 1990 compared with 1989, etc. ... The Korean machine tool industry is now well armed to face a less easy economic climate and then bounce back.

In any case, the medium- to long-term prospects are positive to the extent that the development of machine tools is a base for the promotion of high-tech industries, which for Korean industry are the great challenge of the years ahead. The Government, which in October 1989 proposed an integrated project for the development of the high-tech industries, has set up an "Interministerial Commission for the Development of High Technologies" involving microelectronics, mecatronics, new materials, advanced chemistry, biotechnology, optics and aerospace. These manufactures should increase from 9,400 billion won in 1989 to 93,400 billion won in the year 2000, which would enable Korea to increase its share of the world market for high tech products from 1.4 per cent in 1987 to 3.2 per cent in the year 2000.

25/ Cf. numerous references in Korea Business Review, Korea Economic Journal, Korea Herald.

For this purpose, the Government would have to contribute 3,888 billion won between 1990 and 1994 in the form of loans (and tax reductions) to develop research and development in the high technologies specified above.

These decisions which reflect a declared intention to increase the rate of implementation of advanced technologies, add plausibility to the estimates of demand made in the field of numerically controlled machine tools and robots.

Table 38: Estimates of demand for numerically controlled machine tools
(units)

Client sectors	1987	1990	1995	2000
Machine tools and metal products	609	1 106	2 038	3 754
Cars and components	715	1 235	3 074	7 650
Electrical and electronics industries	136	196	345	609
Precision machines	308	559	1 030	1 899
Exports	110	371	1 377	5 115
Other	244	316	486	748
Total	2 122	3 783	8 350	19 775

Source: "Mecatronics", KIET (October 1989).

The demand for numerically controlled machine tools is led by the engineering and electronics industries which, excluding exports, account for some 90 per cent of the total, particularly cars and the machine sector (i.e., 381, 382, 384 and 395).

Table 39: Estimates of demand for robots
(millions of won)

1986	1987	1988	1989	1990	1995	2000
5 180	20 390	36 100	61 500	94 300	280 000	620 000

Source: Idem.

The gloomy environment of the end of 1989 and the beginning of 1990 lends an optimistic appearance to these estimates. In fact, these estimates are in line with the dynamic progress which for some years has been a feature of the Korean machine tool industry and which has enabled it to speed up its passage through each stage towards the mastery of increasingly advanced technologies.

ANNEX A

Distribution of enterprises (97) by capital

Capital (millions of won)	Number of establishments	Number of employees	Structure: Number of establishments	Structure: Number of jobs
Less than 100	12	874	12.4	5.2
100 to 499	45	1 077	46.4	21.7
500 to 999	15	1 828	15.5	9.7
1 000 to 1 999	4	390	4.1	2.1
2 000 to 2 999	1	286	1.0	1.5
3 000 to 4 999	4	1 526	4.1	8.1
5 000 to 9 999	5	1 999	5.2	10.6
10 000 to 50 000	7	4 219	7.2	22.4
More than 50 000	4	3 504	4.1	18.7
Total	97	18 803	100.0	100.0

Source: KOMMA.

ANNEX B

Dates of production start-up for some categories of machine tools

Lathes, milling machines, drilling machines, grinding machines, saws, shearing machines, shapers, presses, and rolling mills are among the first machines produced in Korea.

Grinding machines appear at the beginning of the 1980s together with gear-hobbing machines.

Electro-spark erosion machines, together with special machines (1982-1983).

Numerically controlled lathes appear in 1981 together with the first machining centres.

The first numerically controlled milling machines date from 1983.

The wire-drawing machines date from 1982 and pipe-bending machines from 1983.

The most "recent" machines are the numerically controlled grinding machines, 1987, along with numerically controlled electro-spark erosion machines, 1988.

Finally, it is a known fact that the first robots were produced in Korea in 1984.

Source: Machine Tool Statistics Handbook, 1989-1990, KOMMA.

ANNEX C

Price of machine tools in Korea

(In thousands of won)

1. Small and medium industries		
Conventional lathes	400 x 1000 mm	6 920
" "	510 x 1000 mm	8 690
Automatic lathe	O 12	7 400
All-purpose milling machine	1000 x 280 mm	7 800
" " "	2000 x 450 mm	29 000
Vertical milling machine	1600 x 400 mm	21 500
Grinding machine	150 x 300 mm	16 000
Drilling machine	420 mm	1 800
Medium-size electro-spark erosion machine	860 x 500 x 360 mm	20 500
Large-size electro-spark erosion machine	2200 x 1600 x 850 mm	65 000
Gear-hobbing machine	O 660	29 000
" " "	O 800	40 000
Numerically controlled lathe	100 x 100 mm	33 000
Numerically controlled grinding machine	1400 x 600 mm	68 000
2. Large enterprises		
High-speed precision lathe	380 x 750 mm	6 700
" " "	460 x 1000 mm	9 000
" " "	58 x 1500 mm	11 000
Vertical milling machine	1350 x 270 mm	9 740
Horizontal milling machine	1350 x 270 mm	9 960
All-purpose milling machine	1600 x 400 mm	25 500
Radial drilling machine	960 mm	7 500
All-purpose grinding machine	270 mm	18 630
Internal grinding machine	O 200	69 700
Numerically controlled gear-hobbing machine	O 250	125 000
Numerically controlled lathe	510 mm	44 500
" " "	660 mm	55 000
Numerically controlled milling machine	1350 x 310 mm	31 500
Vertical machining centre	990 x 410 mm	52 500
" " "	1510 x 425 mm	69 500
" " "	2000 x 710 mm	165 000
Horizontal machining centre	630 x 630 mm	160 000
" " "	800 x 800 mm	195 000

Prices on the Korean market in June 1989 (rate of exchange: $1 = 667.20 won)

Source: KOMMA.

ANNEX D

Machine tool parks by sub-branch of the engineering industry (ISIC) by category of machine in 1984

	Total	381	382	383	384	385
Chip removal	36 257	9 254	14 581	3 138	7 861	1 423
Lathes	10 937	2 859	4 561	769	2 106	642
Drilling machines	7 486	1 451	3 198	767	1 811	259
Boring machines	1 317	112	562	141	474	28
Milling machines	4 764	1 053	2 130	382	1 034	165
Planing machines	327	73	175	22	56	1
Gear-hobbing machines	814	253	333	42	167	19
Grinding machines	5 878	1 947	1 913	529	1 310	179
Saws	823	212	326	118	154	13
Numerically controlled machines	762	131	366	80	147	38
Others	3 149	1 163	1 017	288	602	79
Deformation	15 480	4 468	4 677	2 911	3 020	404
Rolling mills and forges	1 585	730	653	128	51	23
Presses	7 346	1 716	2 271	1 164	1 942	253
Others	6 549	2 022	1 753	1 619	1 027	128
GRAND TOTAL	51 737	13 722	19 258	6 049	10 881	1 827

Source: Koami Machinery Industry (1986).

ANNEX E

Stocks of machine tools by sub-branch of the engineering industry by age, 1984

Type of machine / Age	Total	2 years	3-4 years	5-6 years	7-8 years	9-10 years	11 years and over
Chip removal	36 257	4 280	4 461	4 372	10 801	5 251	7 082
Lathes	10 937	1 323	1 464	1 363	3 130	1 608	2 049
Drilling machines	7 486	908	832	1 187	2 328	731	1 500
Boring machines	1 317	130	69	69	227	267	555
Milling machines	4 764	669	666	572	1 229	1 026	602
Planing machines	327	8	30	43	86	44	116
Gear-hobbing machines	814	56	71	55	261	232	139
Grinding machines	5 878	531	705	513	2 322	684	1 123
Saws	823	108	148	75	148	120	224
Numerically controlled machines	762	234	134	128	150	92	24
Others	3 149	313	342	367	920	447	760
Deformation	15 488	1 826	2 085	2 679	4 313	1 915	2 662
Rolling mills and forges	1 585	57	280	105	756	230	157
Presses	7 346	891	1 048	994	2 394	859	1 160
Others	6 549	878	757	1 580	1 163	826	1 345
GRAND TOTAL	51 737	6 101	6 546	7 051	15 114	7 166	9 754

Source: Koami Machinery Industry.

The situation in 1984 was marked by a slow-down in investments at the beginning of the 1980s after strong growth during the second half of the 1970s.

ANNEX F

The Whacheon Machinery Works

Whacheon, which does not belong to a large group, has a (paid-up) capital of $US 4 million, and employs 1,000 people in four factories:

3 at Kwangju in the south-west;
1 at Changwon.

Its turnover rose from:

$US 13.4 million in 1982 (3 from exports)
to $US 26.6 million in 1986 (3.6 from exports),
and $US 59.3 million in 1987 (5 from exports).

The first factory was established at Kwangju in 1952 to produce conventional machines. Nowadays numerically controlled lathes are also produced there.

The Changwon plant (heavy industry zone) was set up in 1975. It produces lathes, milling machines and grinding machines, together with numerically controlled milling machines and machining centres.

Two other factories established at Kwangju produce castings (10,000 tons) and gears and other components (capacity 400,000-500,000 units).

The company is moving towards implementing integrated automation (factory automation) involving both CAD (computer-aided design) and CAM (computer-aided manufacturing).

Source: "Guide to the Whacheon 1987/1988".